IMPROVING AND EXTENDING THE MOBILITY EN ROUTE SYSTEM

GRADUATE RESEARCH PROJECT

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Abstract

This research project evaluates the improvements necessary to maintain and extend the effectiveness of the air mobility en route system. Previous research regarding limitations and requirements for air delivery of personnel and material are examined to establish the functionality of the en route system and methods for evaluating its effectiveness. Two previous projects that attempted to optimize location and infrastructure for the en route systems are compared against the most current recommendations being explored at Headquarters Air Mobility Command. The comparison of these projects indicates where consensus exists concerning efforts to ensure the future effectiveness of the overall system. This paper attempts to provide a simplified, consistent way ahead for an incredibly complex and expensive mobility system that is critical to meeting the current and future needs of the warfighter.

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I. Introduction

Background

In recent years the National Military Strategy has moved away from a focus on major military conflict as greater emphasis has been placed on engagement and deterrence. A significant factor in ensuring effective engagement and deterrence is the ability to project power rapidly, consistently, and enduringly. The ability to deploy the right force with the right equipment in the necessary timeframe over long distances is completely dependent upon the Air Force's distinctive capability of Rapid Global Mobility. This capability in turn is dependent upon having the facilities, resources and personnel available to support the mobility mission. This critical support infrastructure is what constitutes the mobility en route system (ERS).

There are two major parts to the overall en route system which are administered primarily by the Air Mobility Command (AMC). The first is a series of 13 major, permanent bases that are designed to provide immediate support for all mobility missions on a daily basis which can be seen in Figure 1. The second portion is a collection of airfields that can be accessed on a contingency or as-needed basis. Operating personnel and equipment are placed at such locations only on a temporary basis. AMC refers to these airfields as cooperative security locations (CSLs) because of the high amount of coordination required with the host nation to ensure infrastructure maintenance and resource availability. These locations are also referred to as contingency support locations, thus using the same acronym and having a very similar intent.

Figure 1. The Current En Route System
(From Sere, 2005, p. 3)

Four forums have been created in order to ensure proper advocacy for en route locations as well as an appropriate and balanced strategy, each being know as an en route infrastructure steering committee (ERISC). The first of these creations, established in 1996, was for the European theater, thus being called the EERISC. See Appendix A to view the most recent charter for this organization.

During the first two years of its existence, the EERISC working group was able to establish a long-term basing strategy, which allowed for the loss of one of the six European en route bases during an operation while still achieving full throughput using the remaining five bases. This became known as the "six lose one" strategy. Based upon this strategy, the committee successfully advocated for investment in infrastructure projects that made it possible for the European ERS to meet the requirements that had been established in 1995 by the Mobility Requirements Study Bottom Up Review Update

(MRS BURU) for operations into the Southwest Asia (SWA) area of responsibility (AOR) (McVicker, 2002).

This breakthrough achievement made the formation of a similar body for the Pacific theater highly desirable because the two major regional conflict (MRC) construct in use for force sizing at the time envisioned a deployment of similar complexity based upon renewed hostilities in Korea for which the Pacific en route structure was inadequate. (See Appendix B for the PERISC charter.) This has further led to the development of a global committee (GERISC) as well as a Central Command or CENTCOM committee (CERISC).

The CERISC is clearly a continuation of the previously formed committees with a specific geographic focus. It is interesting to note that the airfield infrastructure in the CENTCOM AOR has grown to the point of providing en route support in sufficient and sustained operations to merit a separate committee. The GERISC is different from the other committees in that it maintains a global perspective, allowing it to balance the needs of the various theaters with the resources available. Such a committee meets the requirement stated in a Government Accountability Office (GAO) report on airfield management for a "unified management structure" that could provide "strategic clarity, comprehensiveness, and organizational commitment" in its advocacy for the en route system as a whole (Meredith and Nelson, 2001: 4).

Research Focus

The requirements that the en route system must be capable of meeting are incredibly demanding and highly stochastic. As such, the system must be structured so as

to be highly flexible and dependable while minimizing the costs associated with system maintenance. This research will attempt to look at what ERS improvements and changes are currently being advocated by AMC and compare those to studies which have attempted to optimize en route structure using various analytical methods. While most of the research is based primarily upon strategic airlift use by C-17 and C-5 aircraft, consideration for tanker assets and other airframes will be examined as applicable.

Research Objective and Questions

The hope is that some measure of consensus between command advocacy and independent modeling can be found so that a consistent and thoroughly supportable en route plan can be advocated. As such, the following questions will be explored:

1. What improvements at current en route locations are most necessary or provide the greatest return on investment?

2. What additional permanent en route locations are necessary or exhibit the most promise for return on investment?

3. What CSLs need to be established and what is the proper level of investment at each location?

II. LITERATURE REVIEW

This chapter begins by examining studies that have been undertaken by the Department of Defense (DOD) in an effort to quantify the mobility capabilities of the DOD as a whole. The requirements associated with large unit movements will then be examined to provide an understanding of exactly what level of effort the ERS is expected to support. Finally, current plans for en route structure being advocated by AMC will be examined, along with recent academic efforts that have attempted to find optimal solutions for en route locations and system capability.

Mobility Studies and Their Implications

In the aftermath of Operations Desert Shield and Desert Storm many military planners voiced concerns regarding the amount of time it had taken to deploy an adequate military force to defend Saudi Arabia from Iraqi aggression. While Saddam Hussein had been unwilling to press his numerical advantage because of a focus on consolidating gains, there was no promise (and in fact very little hope) that future encounters would allow for such an extended deployment timeline. The only solution was to assess the capabilities of the DOD mobility system as a whole in order identify limiting factors and then deal with those factors appropriately.

The initial study was called the Mobility Requirements Study (MRS) which was initiated in 1992. The overall movement requirement was based upon a single MRC very similar to what had just been completed in the Middle East. The locations to which the MRC-capable force would hypothetically be deployed were varied in order to examine the worldwide mobility capability of such a force. Ultimately this study advocated for

additions to several programs including C-17 acquisition, prepositioned stocks, a strategic mobility program for Army forces, and development of the large, medium-speed, roll-on/roll-off (LMSR) ship.

Shortly after the MRS was finalized, the strategy for future engagement began to envision the need to engage in two nearly-simultaneous MRCs. This drove a significant change to the MRS planning factors, and the resulting study became known as the Bottom-Up Review Update, or MRS BURU, which was completed in 1994. The results of this study highlighted the need for significant inter-theater strategic airlift and increased investment in prepositioned stocks to minimize the distance over which critical equipment and supplies would have to be moved.

Significant changes to the military strategy over the next several years once again drove a need to reassess the capacity and effectiveness of the mobility system. The Mobility Requirements Study – 2005 (MRS-05) took place in 2000 with a focus on the mobility system needs and capabilities for deploying a combat force in 2005. Rather than being an analysis of capability at that time, it focused on the effects of programmed changes to meet a future need. This switch to a future state-centered approach was dominated by a new emphasis on participation in smaller scale contingency operations (SSCs) along with the previous requirements to support MRCs. In order to plan for the possibility of engaging in multiple SSCs, with or without ongoing MRCs, a range of total capacity for the system was established. The force structure that the services chose to fund in order to meet the MRS-05 requirements tended to be at the lower end of this range because such a force was affordable and the lack of forces to support the upper range was considered an acceptable risk (OSD, 2005).

The most recent comprehensive study is the Mobility Capabilities Study (MCS) which was chartered in 2004 and completed in 2005. While accounting for ongoing changes to provide an update to the MRS-05 report, MCS also focused on providing a construct to smooth out peaks in demand caused by periods of maximum surge over a limited timeframe. In essence, this was the first study which focused on balancing daily ongoing demands with those resulting from the initiation of MRCs or SSCs.

Ultimately, the MCS concluded that "projected capabilities are adequate to achieve U.S. objectives with acceptable risk" at least into the next decade (OSD, 2005: 7). This includes a period of peak demand on the mobility system supporting two MRCs, multiple homeland defense and civil support missions, other ongoing contingencies, and continuing support of all other worldwide DOD missions. It is critical to note that this conclusion is based upon the military being fully mobilized (all National Guard and Reserve forces available) along with full Civil Reserve Air Fleet (CRAF) and Voluntary Intermodal Sealift Agreement (VISA) participation.

Of particular note for the purposes of this research paper is the MCS's determination that "overseas infrastructure, not the number of available aircraft, remains the fundamental constraint when attempting to reduce delivery timelines associated with large-scale deployments." (OSD, 2005: 8) Such a conclusion clearly emphasizes the need for a sound strategic plan for long-term health of the ERS. A new system study, known as the Mobility Capabilities and Requirements Study (MCRS) is ongoing, and its findings are expected to be released during the current year. No information on its results is yet available, but it is doubtful that the shortfalls of the ERS identified in previous studies will be reported as fully rectified.

Deployment Requirements and Airfield Issues

The effort to properly size and sustain the en route mobility system must be based upon reasonable and validated requirements. The ongoing transformation initiative of the Army is a critical part of the overall mobility requirement. The basis of this transformation is the creation of Brigade Combat Teams (BCTs) small enough in size and weight to be rapidly transportable, yet heavy and lethal enough to provide significant defensive capability and to perform offensive operations. First advocated by the Army Chief of Staff in 2000, General Eric Shinseki, the BCT is designed to be the future force, not just a niche force (Vick and others, 2002). The first BCTs were designed around the recently fielded Stryker vehicle, thus being called SBCTs. Future BCTs will be designed around use of the Army's Future Combat System (FCS) family of vehicles which will be fully networked and include various unmanned or robotically controlled vehicles to complement those that are conventionally manned. Such future BCTs are referred to as the Objective Force, and the original Army goal was to have such a BCT of that force deployed anywhere in the world 96 hours after first liftoff, a division in 120 hours, and five divisions in 30 days. Ultimately, such a deployment capability is a quantum leap from that supportable with current force structure and equipment.

A study produced by Vick and others for RAND's Project AIR FORCE in 2002 went to great lengths to examine the deployment of the SBCT. While this study did not examine the use of specific en route locations, it did show many factors which made fulfillment of the Army's four-day deployment goal highly unlikely. The number of aircraft required to carry the more than 16,000 short tons of equipment and over 4500 personnel is massive (Vick and others, 2002: 17). Limited offload rates at expected

destination airports severely restrict the ability to have the SBCT fully deployed in the desired timeframe. While the Army limited its goal for division deployment based on times required to gather, pack and board, it quickly became apparent that the unload operations were a much greater restriction to meeting deployment goals than any other factor. The study ultimately concluded that despite the feasibility of SBCT deployment by air within required timelines being doubtful, it was clear that air transport was still the best option for meeting the shortest probable timelines overall (Vick and others, 2002: 117).

Although Vick and others did not look at en route restrictions, an earlier RAND report had attempted to model restrictions on throughput at en route locations based upon airfield capacity (Stucker and Williams, 1999). This report came to two important conclusions regarding the general effect that en route locations would have on throughput. The first was that limitations at en route locations would reduce total cargo throughput by approximately 20 percent. Second, ground time estimates used by AMC underestimated the amount of time normally required for cargo loading and aircraft servicing, resulting in total delivery being overestimated by up to 13 percent. Since these erroneous planning factors were still in use for the Vick and others study, it is logical to conclude that the timeline for the SBCT deployment would be even further delayed based on en route limitations.

In a more determined effort to account for restrictions on the SBCT deployment timeline due to en route limitations, Gill (2005) brought together issues identified in several previous studies and examined them using both stochastic spreadsheet models and discrete event simulations. The results of this modeling effort showed once again

that the en route structure would significantly restrict the flow of materiel and, thus, further extend the deployment closure timeline. While Maximum on Ground (MOG), e.g. the space available for parking and servicing aircraft, proved a significant constraint, the greatest sensitivity was shown to relate to hot cargo parking spots, that is parking locations specifically designed to accommodate aircraft carrying hazardous cargo such as explosives and ammunition (Gill, 2005).

In the case of the Stryker Brigade, it was assumed that half the aircraft loads would require this specialized parking due to vehicles being combat loaded with ammunition in preparation for immediate use upon offload at final destination. The 50% hot cargo parking is not a stated Army requirement, but an assumption that was used by TRANSCOM in a 2002 study of the SBCT deployment which seemed prudent for Gill to carry over to his study (Gill, 2005: 23). If vehicle and cargo loads were configured to reduce the number of aircraft requiring hot cargo parking (by consolidating hazardous loads into fewer aircraft) it is possible that this requirement would be reduced and closure timeline sensitivity would be reduced. Such a reduction in hot cargo requirements would not, however, bring closure times within the Army goal of 96 hours.

The Stucker and Williams study, as previously mentioned, went to great lengths to establish restrictions or choke points created by the limited capacity of en route airfields. Their findings were further reinforced by the conclusions reached in a GAO report highlighting issues of deployment readiness (Meredith and Nelson, 2001). This report focused on three main areas: capacity of en route airfields, causes of shortfalls and corrective plans, and whether DOD had the proper management structures in place to efficiently and effectively operate the ERS.

Ultimately the report found that sufficient capacity did not exist, but DOD was taking appropriate steps to address such shortfalls. One note of interest was the expanding cost of closing the gap between requirements and system capacity, which at the outset of the study DOD estimated at $1.2 billion, but by the time the report was completed DOD had increased its estimate to approximately $2 billion (Meredith and Nelson, 2001: 9). It was expected that more than half the required funds would come from host nations (namely Germany and Japan) or allied forces (for bases supporting NATO operations). While $2 billion seemed adequate for rectifying capacity shortfalls, the report emphasized the need for significant oversight of ongoing and future projects as funding could quickly disappear in a highly competitive budget environment.

Beyond the investment requirements a significant portion of the report highlighted challenges in executive level management of the ERS, or what was termed a lack of executive leadership. The report recommended the following:

1. Make one organization responsible for strategic management and coordination of overall ERS operations during peacetime
2. Develop a formal strategic plan and monitoring system for the ERS
3. Develop an overall cost-benefit study to document the rationale for plans to repair and improve the ERS
4. Include information on ERS limitations and how they affect the Department's strategic mobility performance in DOD's performance plan and report

In essence, the study recommended a single head for a total en route organization with proper tracking tools and associated reporting requirements. The need for such a body can be better understood by examining the numerous agencies with responsibility for

various portions of the ERS which must be fully coordinated to ensure smooth and robust system function. Such an overview is provided in Figure 2.

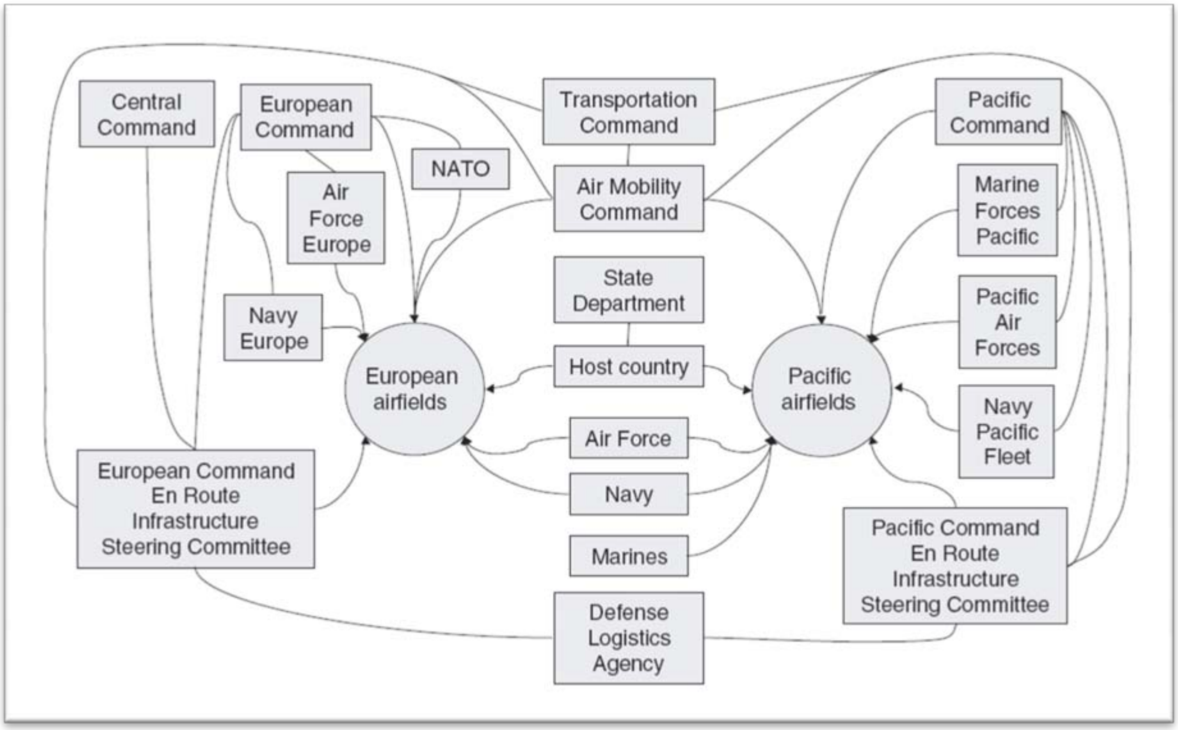

Figure 2. Organizations with Responsibility for the ERS
(From Meredith and Nelson, 2001, p. 20)

Ultimately the DOD could show no overarching strategic plan. Studies such as MRS-05 indicated where weaknesses and risks existed, but no study or report included a plan with a timeline and budget estimates to rectify weaknesses or mitigate risks. As such, it was impossible for the study's authors to say that any strategic plan existed at all. DOD was not necessarily interested in implementing the study's recommendations, but the overall management was clearly deficient.

Tools for Strategic Airlift Analysis

The importance of MOG was mentioned above in relation to predicting restrictions on system throughput. Two sources are essential for properly planning and analyzing strategic airlift. The first source is Air Force Pamphlet 10-1403, *Air Force Planning Factors*, which provides standard factors such as ground times for various required services. Such factors help to simplify the planning process by providing easily calculated yet fairly accurate estimates (on average) of times for various aspects of aircraft operations and ground handling. Use of these factors ensures consistent application of natural restrictions which exist in the use of strategic airlift.

For more advanced requirements, Brigantic and Merrill provide numerous formulas specifically for use in mobility applications (2004). While the Air Force Pamphlet is simplified and provides gross, average values, Brigantic and Merrill offer formulas and methods that allow for highly precise calculations that account for numerous variables which must be accounted for in the use of airlift. This enables the ability to dig a bit deeper and plan more thoroughly. For example, working MOG is normally defined as one half the parking MOG. Brigantic and Merrill define MOG on the basis of Limiting Ground Time divided by the Flow Interval. Each of these two factors has multiple inputs which vary from base to base and which also change based on weather conditions, manning and equipment (Brigantic and Merrill, 2004: 652). Thus, the true complexity of operations in the ERS can be better understood using such techniques and associated formulas.

The AMC Plan and Academic Models

Fortunately, the call for the creation of a strategic plan was heeded and today that strategy is being revised. AMC's Strategic Planning Division (AMC/A8X) has produced a "White Paper" for this purpose which is called the "Air Mobility Command Global En Route Strategy". The document is currently in draft form (the latest copy available was version 6.11, obtained from AMC/A8X) and has received numerous comments and recommendations; therefore, it does not yet constitute a finalized strategy, but it is expected to be finalized this summer.

The paper proposes several reforms to the ERS on the strategic level as well as on the operational level. In the European theater, the strategy has long been based upon having six major en route bases and needing only five of those to ensure timely and robust system flow. The revised strategy would link locations based upon geography, thus representing northern, central, and southern routes leading to the critical AOR. This is depicted in Figure 3. Additionally, the new strategy would be based on cross-Atlantic operations rather than just cross-European as has been the focus in the past.

Operational changes would include improvements at Ascension Island and Camp Lemonier in Djibouti to support the southern route. Changes at Lajes Airfield, Azores, Rota Naval Station (NS), Spain, Sigonella NS, Italy, and Souda Bay NS, Crete, all contribute to right-sizing the central route. Opening operations and initiating improvements at the airfield in Constanta, Romania, along with the capabilities at Incirlik AB, Turkey, and Al Udeid AB, Qatar, ensure the ability to support all necessary operations in the CENTCOM AOR. Operations into Africa will remain a challenge due

to the shortage of host nation infrastructure on the continent and a lack of commitment from U.S. authorities to develop bases beyond what is already at Camp Lemonier.

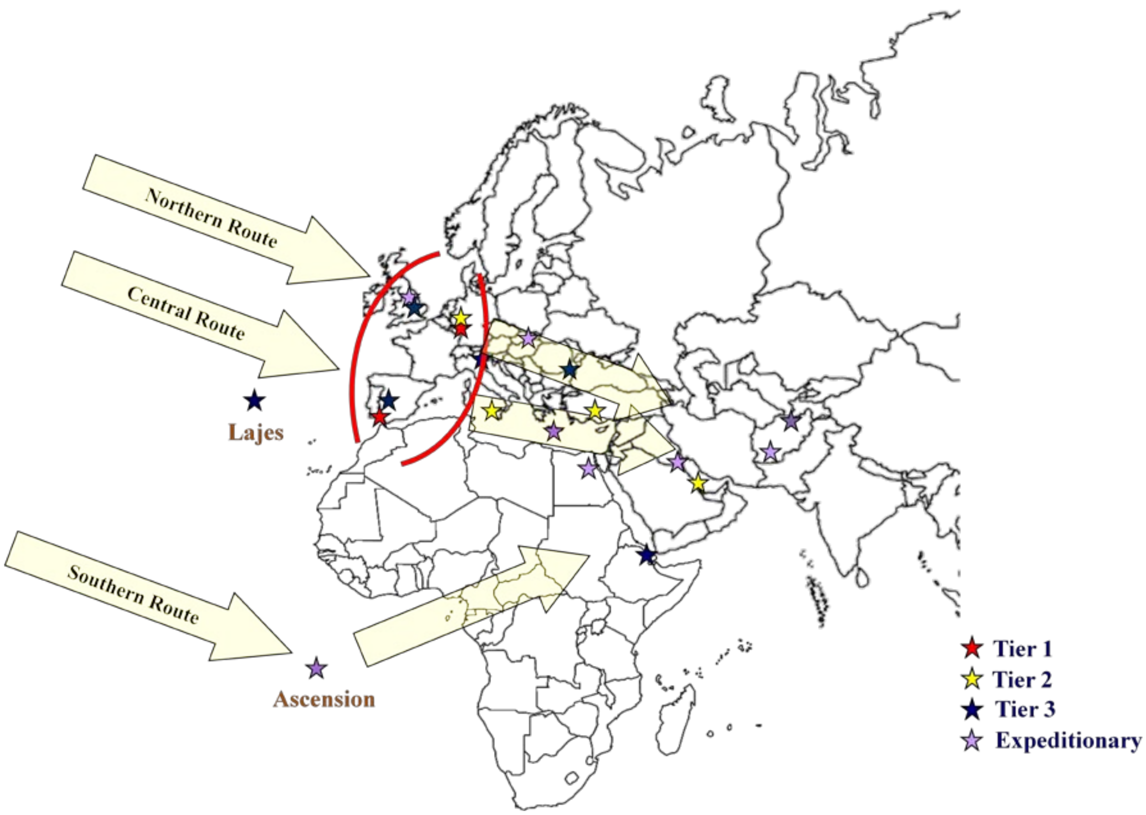

Figure 3. The Three Atlantic Routes
(From AMC/A8X, 2009, p. 21)

For the Pacific routing, no significant strategic changes are advocated. The plan is to continue to maintain two routes since land is not available to support any type of a crossing through the southern Pacific area. Hickam Air Force Base (AFB), Hawaii, and Elmendorf AFB, Alaska, will serve as the primary OCONUS stops with Anderson AFB, Guam, Kadena AB, Japan, and Yokota AB, Japan, providing the major stopover points in the Western Pacific. The Pacific Strategy is shown in Figure 4.

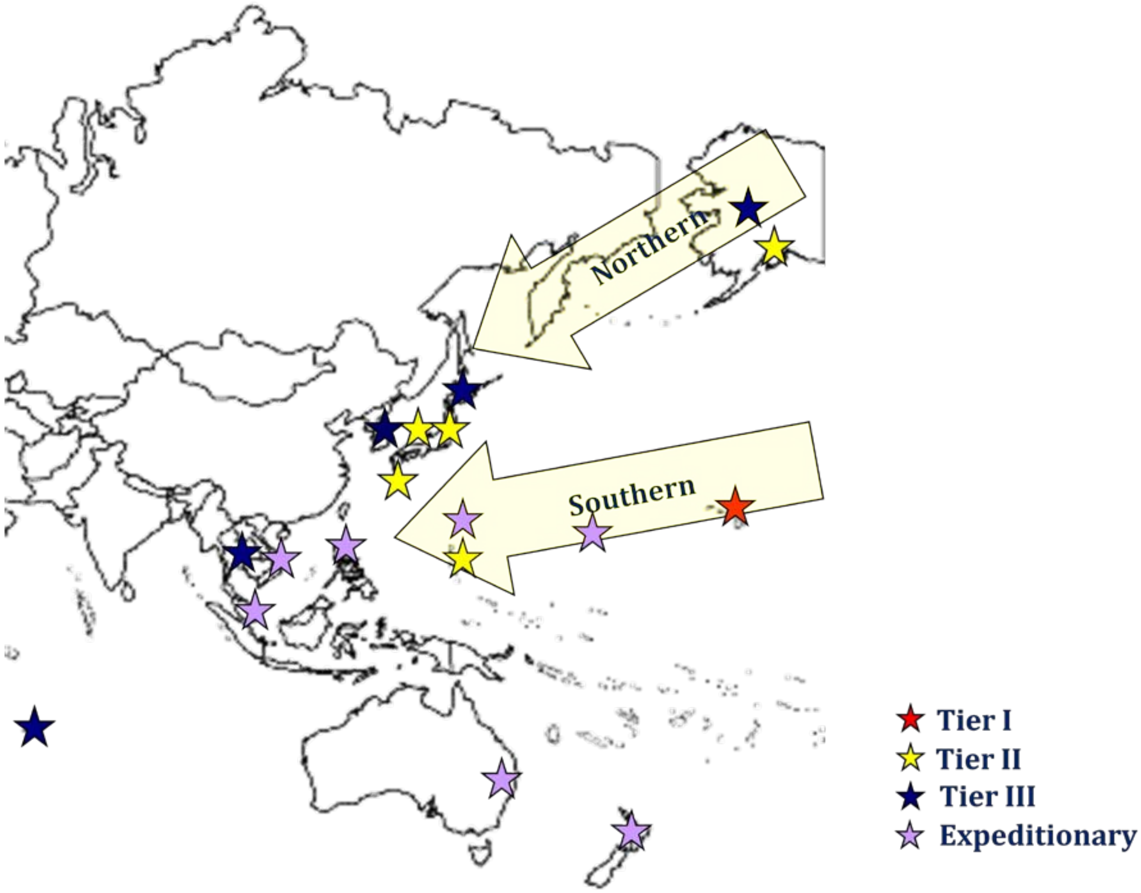

Figure 4. The Two Pacific Routes
(From AMC/A8X, 2009, p. 29)

On the operational level, several changes are recommended. Increased capability at Iwakuni NS, Japan is recommended to absorb surge demands on Yokota AB, whose capabilities cannot be significantly increased due to limited land availability, quiet hour restrictions, and airspace encroachment. The importance of U-Taphao airfield, Thailand is emphasized with freedom of access and good political relations leading the list of its advantages. Changes at Anderson AB, Guam, due to new units and missions being moved there from Okinawa, Japan, will likely make the field too congested for full use

by mobility assets during times of crisis. Thus, it is suggested that agreements be pursued with the airfield on the nearby island of Saipan to serve as an overflow and possible transload location. Ultimately locations across the Pacific may see some changes, but the strategy for using those locations remains the same.

Numerous academic efforts have been undertaken to examine the problems facing the ERS. Some have modeled operations based upon existing infrastructure while others have attempted to quantify limiting factors and then put them in a model to enable prescriptive solutions and possible optimization (Miravite and Schlegel, 2006).

For the purposes of this paper, two studies have particular importance. The first of these is by Sere (2005), which attempted to differentiate between 25 candidate airfields for inclusion in the ERS. His study used six major factors in determining which airfields provided the best possible additions, which are as follows:

1. Distance calculations from origin airfields to the candidate airfields on to destination airfields
2. Parking capacity
3. Fuel capacity (storage and distribution)
4. Diplomatic relations with the host country
5. Proximity to major seaports (for intermodal use)
6. Number of airfields which can receive strategic airlift within a predetermined distance (total possible destination airfields)

The resulting list of best candidate bases provides an excellent overview of locations which would be ideal for expanding en route operations in numerous areas around the globe.

The second academic paper of particular interest is by Voigt (2005), which looked at potential en route airfields on the basis of cargo throughput. While Sere focused mainly on distance and delivery network connectivity, Voigt concentrated on the capability to move cargo as a primary value. She examined the value of each location based upon current and possible increased levels of cargo handling capability. Thus, Voigt's study provides a basis for infrastructure improvement at particular locations, which dovetails nicely with Sere's recommendations based upon system connectivity. The results of both academic studies will be fully examined in section IV of this paper

Summary

The mobility en route system for support of AMC's strategic airlift fleet is clearly critical for meeting the national policy objectives and the requirements of combatant commanders. Shortfalls have been continuously identified since the end of the Cold War and no study has shown those shortfalls to have been eliminated. Greater focus on SSCs only creates greater requirements with potentially shorter timelines for delivery. A strategy for the en route system which includes necessary and sustainable increases in the number of locations and proper sizing of support capabilities must be prepared, coordinated, funded and continuously advocated by all affected parties.

III. METHODOLOGY

Analytical Method

Based upon the need for consensus and consistency in creating a strategic plan for the en route system, a simple comparative methodology will be used to attempt to determine if there is consensus concerning what improvements and changes will be most beneficial to the system as a whole. The comparative method is used extensively in the social sciences, particular in the field of political science. In fact, one of the major subdisciplines in political science is comparative politics. The comparative method "indicates the *how* but does not specify the *what* of the analysis" (Lijphart, 1971: 682). In the case of this study, the *what* is the en route system, and the expectation is that a general prescriptive solution can be arrived at.

The comparative method has been applied in numerous ways. In the public policy arena, decisions often have a variety of consequences, some of which are intended and many which are not. Many complex areas, such as decision making in the European Union, can be examined using the comparative method to provide both a general overview of a matter at hand as well as detailed analysis based upon focused and specific factors (Kettunen, 2008). This is exactly what will be attempted in the current study – provide a general overview of some solutions that have been suggested and then examine the justification and rational behind individual suggestions in detail in order to provide a meaningful and supportable strategy.

Data Sources

There are three primary sources that will be examined. The baseline source is the AMC/A8X white paper. Since this is the current way forward proposed by the command that provides oversight, manning, and equipment for the vast majority of the ERS it should provide the most robust overall strategy for system improvement. The other two sources are the Sere and Voigt studies. Their results were based entirely on modeling and are independent of the politics and pressures that are endemic to headquarters functions. Thus, optimal solutions created in a sterile environment will be used to assess the accuracy and supportability of the AMC strategic plan.

Data Analysis

Based upon the foregoing, a basic comparison of results will be conducted. The various conclusions along with reasons for both agreement and disagreement will be established. The effort will be undertaken to establish a clear, supportable, and sustainable path for strategic implementation.

IV. RESULTS AND DATA ANALYSIS

This section will focus on the conclusions that each study presented as the most compelling. Points of agreement will then be identified and validated so as to provide clear recommendations for a way forward. Points of disagreement will then be identified and an attempt will be made to rectify the disagreements if possible or quantify the potential impact that the disagreements might cause (i.e. wasted resources, redundant capabilities, etc.).

AMC White Paper Recommendations

For missions into South America, Palanquero, Colombia, is recommended as a CSL. Pursuit of access in French Guiana for a CSL is also recommended, but no level of capability is specified. Continued use of existing Air National Guard facilities in San Juan, Puerto Rico, and Christiansted, US Virgin Islands, is advocated as these facilities do not require any investment or maintenance to ensure access, as they are fully funded and maintained by separate entities.

For missions into Africa, use of bases near the Mediterranean Sea provides the most significant capacity. Funding for an expanded ramp and fuels infrastructure at Ascension will create significantly greater capacity, but it should continue only as a CSL. Upgrade of Camp Lemonier, Djibouti, to Tier III capability by adding permanent infrastructure appears to be the best option pending emergence of a suitable location in the interior of the continent or on the western coast.

Locations in Europe continue to have the most robust capability as they support the majority of en route missions on a daily basis. Growing Rota's capability to Tier I

status through increased maintenance, refuel and aerial capabilities is the biggest change in Western Europe, along with downgrading Mildenhall to Tier III status. An upgrade to the runway at Sigonella also shows great promise. In Eastern Europe Constanta, Romania, would become part of the ERS to support emerging missions in the region. Papa, Hungary would also be a natural choice for a CSL as the international C-17 unit stands up there.

In the Persian Gulf region, Al Mubarak, Kuwait would be upgraded to Tier II and become equal with Al Udeid, Qatar. Further east, Bagram would need to upgrade to Tier III (already planned by CENTCOM) with Kandahar remaining a CSL.

In the Pacific far fewer changes are needed. The biggest change is to move Iwakuni, Japan, from a CSL to full Tier II capability, though with less than Tier II manning. U-Taphao would receive permanent Tier III capability while Saipan in the Marshall Islands and Cam Ranh Bay, Vietnam would become new CSLs. A comprehensive overview of the proposed ERS is shown in Table 1.

Tier I	Tier II	Tier III	Contingency Support Locations	
Ramstein	Spangdahlem	Mildenhall	Fairford	Palanquero
Rota	Incirlik	Bagram	Christchurch	Antigua
Hickam	Al Udeid	Aviano	Kandahar	Clark
	Signonella	Djibouti	Papa	Ali Al Salem
	Anderson	Eielson	Bahrain	Singapore
	Elmendorf	Misawa	Souda Bay	Saipan
	Iwakuni	Moron	Cairo West	Lajes
	Kadena	U-Taphao	Aruba	Cam Ranh
	Yokota	Diego Garcia	Ascension	
	Al Mubarak	Richmond		
Color Key		Constanta		
Increased Capability		Osan		
Decreased Capability		Wake		
New Location		Kunsan		

Table 1. AMC's Proposed Future En Route System

Sere's Recommended En Route Locations

For missions to South America, Sere only examined a very limited number of possibilities. An en route in Puerto Rico showed the most promise with Ascension in second and a location in Brazil third.

For delivery to Southern Asia (India) several locations were quite promising. Seeb, Oman and Bahrain showed the most promise with Kuwait, U-Taphao, Thumrait, Constanta and Al Udeid following close behind.

The Northeast Asia scenario (delivery to Seoul) demonstrated the ability of Clark to be a positive addition to the ERS while U-Taphao proved adequate for supporting that region as well. Existing locations in Japan and Alaska performed best, which is quite

logical since supporting transport to Korea was one of the primary factors in the bases being established and maintained as they are.

In Southeast Asia, delivery to Dili, Indonesia was assessed. Among existing en routes Kadena, Anderson and Iwakuni scored highest. Clark, U-Taphao, and Singapore were among the best-performing potential en routes.

When looking at Southwest Asia for delivery to Baghdad the clear leaders are Ramstein and Spangdahlem along with Incirlik. Constanta showed great promise as a potential en route, along with Kuwait and Al Udeid.

Delivery to Central Asia was modeled using Lahor, Pakistan as the destination. Constanta, Kuwait, and Al Udeid were among the leaders for potential en routes while Incirlik, Ramstein, and Spangdahlem performed best among existing en routes.

The scenario for Western Africa delivery showed the limitations for selecting new en route locations for servicing the area. None of the potential en routes had a particularly good score, though Constanta was again notable among the top contenders. Lajes, Rota and Moron showed the most promise for transport to Monrovia, Liberia.

The final scenario examined delivery to Waterkloof, South Africa for response in extreme Southern Africa. As would be expected, performance ranged from limited to poor to non-existent. Sigonella, Rota and Moron again topped the list for existing en routes. Thumrait, Seeb, and Moi, Kenya, led the list of potential locations.

Based upon average performance scores across all eight scenarios, the most important existing en routes were deemed to be Ramstein, Spangdahlem, and Incirlik. Top overall performers among potential en routes were Constanta, Kuwait, and Al Udeid. Bases in the Pacific appeared to perform poorly overall, but the scenarios chosen

naturally drove overall more towards a European or Middle Eastern best performance simply based upon distance factors. This may seem biased, but such weighting was based upon expectations of where crises (and, thus, the need for timely delivery) were most likely to arise.

Voigt's Recommended Locations and Actions

Destination locations for Voigt's study were identical to those used by Sere, but were presented in a different order in her paper. For the sake of simplicity, they will be presented here in the same order that Sere used. It is also important to note that Voigt examined a smaller number of potential en route locations due to the complexity involved in modeling three levels of throughput capability at each location.

The South America scenario again showed the importance of en route locations in Puerto Rico, Ascension and Brazil for meeting requirements in the region. No other locations in Central or South America were examined beyond these three, so they led the list simply based on all other candidates being much further from the goal location.

For the Southern Asia delivery Seeb, Bahrain, and U-Taphao showed the most promise with current infrastructure. With significant improvements Thumrait would edge out U-Taphao for third in the order.

The Northeast Asia scenario showed U-Taphao to be a winning choice for a potential en route. Only with significant improvements leading to near unconstrained MOG could Clark begin to rival U-Taphao's capability. Results were essentially identical for the Southeast Asia destination – U-Taphao leading at all times until Clark achieved unconstrained MOG.

For Southwest Asia Bahrain, Burgas, Constanta, Kuwait, Seeb, and Thumrait all proved to have excellent delivery capability. With significant improvements Constanta and Burgas moved to the front of the list because of cooler average temperature enabling higher departure weights.

The Central Asian scenario again highlights the capability available through U-Taphao. Seeb and Bahrain perform very well with current capabilities and Thumrait moves up the list significantly with potential infrastructure improvements. Worthy of note here is the fact that U-Taphao is the only location in Voigt's model that had the ability to support delivery to Central Asia from the east.

Delivery to Western Africa in the model showed how limited support on the continent drives unusual en route locations. Augusto Severo, Brazil along with Ascension and Burgas, Romania, provided the greatest current delivery capability. With even modest infrastructure improvements, Dakar, Senegal moves to the front of the list for its delivery capability.

The final destination in Southern Africa amply demonstrates once again the great difficulty in reaching that area of the globe. Moi International in Kenya, Ascension and Seeb led the list as only five of the bases in the model qualified to deliver because of being within 3500 NM of the destination. With modernization Moi became an even better candidate.

Rolling up all the results shows the pre-eminence of U-Taphao, Ascension and Bahrain overall. Each finished as a top 3 provider more than 10% of the time across all scenarios run. Their ability to deliver to numerous potential locations showed them to be the strongest candidates for future upgrades and increased use.

Areas of Agreement

All three studies clearly demonstrate that there is only a limited capability to provide strategic lift into South America and Africa. While it would seem desirable to make such capability much more robust for these areas, the reality of limited requirements for these areas coupled with the limited ability of bases supporting these areas to serve other areas outside of their limited geographic location makes investment difficult to justify. One exception is the need to make improvements at Ascension as it is capable of supporting both theaters, making the potential return on investment double that of other locations serving either of these areas.

The potential for U-Taphao and Constanta to provide significant throughput also comes through in all three studies. While it is impractical to model or assess the utility of all potential airfields, particular airfields lend themselves to regular assessment and are logical points to examine for expansion and improvement. Ultimately there are cases in which every potential and current en route location has the probability or providing significant support to warfighting, peacekeeping, humanitarian relief or other operations which are dependent upon strategic mobility for supply. Thus, choosing the right locations and the right level of infrastructure and support is no easy task.

Areas of Conflict and Their Causes

It would be inappropriate to state that there are conflicts between the three studies compared here. There are clearly areas that one study addresses that the others may not, but that does not put them in a state of conflict. This is simply a result of the need to limit options under examination in order to be able to draw meaningful conclusions in a

reasonable timeframe from constrained models. Numerous locations and associated improvements advocated by AMC/A8X simply were not within the scope of the other studies. That does not render them any less important, it just simply makes it impossible to fully validate them on the basis of this research effort.

V. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Conclusions

The focus of this research effort was to use comparative methods to establish and validate improvements and changes to the ERS. While comparison of results from different studies was possible and enlightening, it did not provide a comprehensive solution set regarding the entire system. Because of the complexity of the ERS combined with the numerous requirements and expectations of the system, it is probably overly optimistic to think that a single research effort could ever provide comprehensive results. Ultimately the limited number of options examined in the Sere and Voigt models allow for only limited conclusions to be reached regarding en route laydown and structure.

The most certain recommendations that come from comparing the various results is that the airfields at Ascension Island, Constanta, Romania, and U-Taphao, Thailand, are the locations that show the most promise among candidate airfields for increased use and infrastructure investment. While these are the only areas where a clear consensus emerges, there are other points that can be emphasized. First, none of the recommendations in the AMC/A8X strategy are contra-indicated by the other studies. The areas where there is no consensus are caused by options that simply were not considered by Sere or Voigt. Thus, the AMC recommendations can be accepted as valid and supportable because there is nothing to contra-indicate the recommendations. In the absence of alternate plans, it is prudent to go with the best plan available.

Ultimately the success of the ERS depends upon properly applying the movement formula used at the Joint Movement Center (JMC) for EUCOM:

Planning + Coordinating + More Coordinating + Flexibility in Execution =

Mission Success!

(McClean and Henson, 2004). Creating a coherent, implementable, and sustainable ERS strategy is all about planning and coordinating, but flexibility to deal with budget constraints, international politics, and random events must always be an inherent part of the overall system.

Recommendations for Further Research

The most obvious next step to follow this research would be to obtain the models created by Sere and Voigt and use AMC/A8X's recommended locations in those models, along with those already in those studies. Also, the final destination airfields in those studies could be changed to reflect locations where operations are more likely to take place in the future. The first benefit of extending both models is that a complete validation of the AMC plan would then be possible along with clearly identifying where better alternatives might exist. Secondarily, the various locations could be assigned values based on how they perform overall in order to be able to rank-order or stratify among locations. Thus, when budget or other limitations make it necessary to choose among projects or locations it would be a fairly straightforward process to advocate the appropriate choice.

One area that can certainly use attention is an effort to better model mobility as a system rather than individual locations. The AMC white paper emphasized the strategic

value of a system view over a location view; Sere and Voigt both acknowledged that more meaningful results could be achieved by using their methodologies with more robust models that allowed for more than a single en route stop. Especially in the case of Africa it would be more accurate to use multiple en route bases in a line (i.e. Charleston to French Guiana to Ascension to Namibia). The ability to investigate all possible combinations of origin, en route, and destination options would allow identification of the optimal overall system.

One item that was not discussed in the requirements for the en route system is support for Aeromedical Evacuation (AE) operations. From the Korean conflict to the end of the 20th century AMC operated dedicated AE aircraft. Almost all AMC assets have now become capable of carrying patients and AE crews, but none of the literature concerning the ERS indicated how or even if AE is considered in the system. Since the change to a full AE-capable fleet there has not been significant stress placed on the ERS due to AE requirements because of very low casualty rates overall. A research report by Berry (2002) concerning the interface of AE and the ERS provides an initial start in this direction, but operations in Iraq since that writing have produced casualty rates that would allow much greater fidelity in examining system behavior under increased requirements. Such research would help to address shortfalls that would otherwise not become apparent until a massive AE requirement exposes deficiencies in the system.

A final area that shows great promise for research is to examine the changes that extending the optimal range of C-17s will drive in the ERS. The 71st C-17 came off the production line with an extended range (ER) fuel tank that allows upload of an additional 9,500 gallons of fuel. Every C-17 produced since then has been ER equipped. This

provides over 2 hours of additional flying time, thus extending the optimal unrefueled range to more than 4,000 NM. Every study and model of the ERS is based upon the 3,500 NM optimum range of the non-ER C-17s, which now constitute less than half the total C-17 fleet. The first 70 C-17s are scheduled for a retrofit program that includes an ER kit (AMMP, 2007: 60). Thus, the single greatest factor determining optimal distance between en route locations is changing, but there has been no effort yet to restructure the ERS to account for this fact.

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Appendix A: European En Route Infrastructure Steering Committee Charter

A. Purpose

This charter defines the roles and responsibilities of the EERISC. This committee will provide direction and staff for the resolution of current and future European en route infrastructure issues. This charter will be reviewed at least annually.

B. Applicability

This charter applies to EUCOM, CENTCOM, and TRANSCOM directorates, components, and combat support agencies.

C. Mission

The EERISC and Working Group serve as forums for EUCOM and TRANSCOM representatives to research, identify, prioritize, and act on current and future en route infrastructure-related initiatives. The scope of the EERISC will encompass an end-to-end view of en route infrastructure issues. The mission objectives are as follows:

1. Develop and guide en route strategy to include oversight of tanker issues.
2. Ensure successful implementation of current and future en route infrastructure initiatives.
3. Ensure current and future European infrastructure requirements are documented.
4. Identify information/data requirements to adequately analyze European infrastructure.
5. Deconflict MILCON/NATO/Host nation funded construction projects to ensure minimum impact on OPLAN support.
6. Determine necessary tasking and priorities for supporting steering committee objectives.

D. Organization

Standing members will be one primary and one alternate representative with decision-making authority in support of either the Steering Committee or Working Group.

1. Executive Steering Committee

The Executive Steering Committee is co-chaired by USEUCOM/J4 and USTRANSCOM/J5 or their designated representatives.

2. Working Group

The Working Group consists of functional experts capable of addressing EERISC issues from the following organizations:

USEUCOM	HQ AREUR	ODC Spain
USTRANSCOM	HQ USAFE	HQ ARCENT
USCENTCOM	HQMARFOREUR	HQNAVCENT
USSTRATCOM	HQ SOCEUR	HQ MARCENT
JFCOM	DLA	HQ CENTAF
HQ AMC	721 AMOG	
HQ NAVEUR	NAVSTA Rota	

Additional staff from other organizations may be required to join the Working Group to assist in the progression of specific issues, as the situation dictates.

E. Responsibilities

1. Executive Steering Committee

The Executive Steering Committee provides strategic direction for current and future en route infrastructure initiatives and serves as the approval authority for Working Group issues.

2. Working Group

The Working Group solves issues at the lowest level possible by identifying and recommending improvements to the European En Route Infrastructure. It also reports action item status to the Executive Steering Committee for approval or for further guidance of unresolved issues. The Working Group identifies office of primary responsibility (OPR) for resolving issues and monitors other issues that may affect the en route system, e.g. tanker beddown at en route bases. Sub-working Groups will be formed as necessary to address specific issues.

F. Procedures

The Executive Steering Committee directs the Working Group. The Working Group meets twice yearly, once in conjunction with the Global En Route Infrastructure Steering Committee, or as necessary. Approximately, 30 days prior to each scheduled meeting, a joint decision will be made on the following choices due to issue status:

1. Hold meeting as scheduled with required travel
2. Hold meeting using VTC
3. Cancel scheduled meeting

After each meeting, EUCOM J4 and TRANSCOM J4 will coordinate, endorse, and publish an update message incorporating a summary of issues discussed, tasks assigned, the EERISC way ahead, and a proposed date for the next scheduled meeting.

Appendix B: Pacific En Route Infrastructure Steering Committee Charter

A. Purpose

This charter defines the USPACOM En Route Infrastructure Steering Committee (PERISC) and Working Group. These groups will provide direction and staff, respectively, for the resolution of current and future USPACOM en route infrastructure issues. This charter will be reviewed at least annually.

B. Applicability

This charter applies to USPACOM and USTRANSCOM directorates, components, and combat support agencies, and USPACOM sub-unified commands.

C. Mission

The PERISC and Working Group serve as forums for USPACOM and USTRANSCOM representatives to research, identify, prioritize, and act on current and future en route infrastructure-related initiatives. The scope of the PERISC will encompass an end-to-end view of en route infrastructure issues. The mission objectives are as follows:

1. Develop and guide en route strategy.
2. Ensure successful implementation of current and future en route infrastructure initiatives.
3. Ensure current and future PACOM infrastructure requirements are documented.
4. Identify information/data requirements to adequately analyze PACOM infrastructure.
5. Deconflict MILCON/Host nation funded construction projects to ensure minimum impact on OPLAN support.
6. Determine necessary tasking and priorities for supporting steering committee action plan.

D. Organization

Standing members will be one primary and one alternate representative with decision-making authority in support of either the Steering Committee or Working Group.

1. Executive Steering Committee

The Executive Steering Committee is co-chaired by USPACOM/J4 and USTRANSCOM/J5. Alternate members are USPACOM/J40 and USTRANSCOM/J5-V.

2. Working Group

The Working Group includes USPACOM and USTRANSCOM staff, component, sub-unified command, and DLA action officers. The Working Group consists of functional experts capable of addressing PERISC issues from the following organizations:

USPACOM/J4 (co-chair)	USTRANSCOM	HQ USARPAC
TRANSCOM/J5 (co-chair)	DLA	HQ PACFLT
USPACOM/J3	HQ AMC	HQ MARFORPAC
USPACOM/J5	HQ MSC	HQ PACAF
USPACOM/J07	HQ SDDC	HQ USFJ
USPACOM/J08	HQ USFK	HQ SOCPAC
		HQ ALCOM

E. Responsibilities

1. Executive Steering Committee

The Committee provides strategic direction for current and future en route infrastructure initiatives, reviews the Working Group's recommendations, and submits issues for prioritization and action. In addition, the steering group will provide periodic status reports to USPACOM and USTRANSCOM.

2. Working Group

The Working Group will solve issues at the lowest level possible by identifying and recommending improvements to the full spectrum of en route infrastructure considerations. They will also report action item status to the Executive Steering Committee. The Working Group will provide feedback to the Executive Steering Committee. Status reports of unresolved issues will be submitted to the Steering Committee for further guidance.

F. Functions

PERISC sub-working groups will be formed as deemed necessary based on initiatives identified. Sub-working groups will identify solutions to the working group's tasking(s). Subsequent PERISC meetings will develop additional action items and specific OPRs for resolution of issues.

G. Procedures

The PERISC Working Group receives its direction from the Executive Steering committee. The Working Group will meet quarterly, or as deemed necessary in conjunction with PERISC meetings. Minutes will be taken and a recorder will be provided on a rotational basis from amongst PERISC Working Group member organizations. The Working Group will submit periodic reports through the Executive Steering Committee to USPACOM and USTRANSCOM.

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Glossary

AB	Air Base
AE	Aeromedical Evacuation
AFB	Air Force Base
AFRICOM	United States Africa Command
AMC	Air Mobility Command
AOR	area of responsibility
AMMP	Air Mobility Master Plan
BCT	Brigade Combat Team
CSL	cooperative security location
CENTCOM	United States Central Command
CERISC	CENTCOM En Route Infrastructure Steering Committee
CRAF	Civil Reserve Air Fleet
DOD	Department of Defense
EERISC	European En Route Infrastructure Steering Committee
EUCOM	United States European Command
ERS	en route system
FCS	Future Combat System
GAO	Government Accountability Office
GERISC	Global En Route Infrastructure Steering Committee
HQ	Headquarters
IBCT	Interim Brigade Combat Team
JMC	Joint Movement Center
LMSR	large, medium-speed roll-on/roll-off
MILCON	Military-funded Construction
MRC	Major Regional Conflict
MRS	Mobility Requirements Study
MRS-05	Mobility Requirements Study 2005
NM	Nautical Mile
OPLAN	Operational Plan
OCONUS	Outside the Continental United States
OSD	Office of the Secretary of Defense
PACOM	United States Pacific Command
PERISC	Pacific En Route Infrastructure Steering Committee
MRS BURU	Mobility Requirements Study Bottom Up Review Update
NS	Naval Station
SBCT	Stryker Brigade Combat Team
SOCOM	United States Special Operations Command
SOUTHCOM	United States Southern Command
SSC	Small Scale Conflict
SWA	Southwest Asia
VISA	Voluntary Intermodal Sealift Agreement

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14. ABSTRACT

This research project evaluates the improvements necessary to maintain and extend the effectiveness of the air mobility en route system. Previous research regarding limitations and requirements for air delivery of personnel and material are examined to establish the functionality of the en route system and methods for evaluating its effectiveness. Two previous projects that attempted to optimize location and infrastructure for the en route systems are compared against the most current recommendations being explored at Headquarters Air Mobility Command. The comparison of these projects indicates where consensus exists concerning efforts to ensure the future effectiveness of the overall system. This paper attempts to provide a simplified, consistent way ahead for an incredibly complex and expensive mobility system that is critical to meeting the current and future needs of the warfighter.

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